

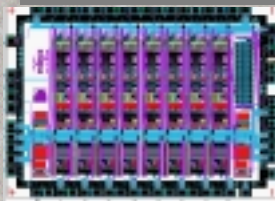
# Brookhaven National Laboratory Microelectronics for Advanced Detectors

The Instrumentation Division develops full custom microelectronics solutions for a variety of applications and is active in collaborative research with industry. Areas of expertise include:

- ultra-low noise preamplifiers
- precision analog signal processing
- data acquisition and control for large experiments
- CdZnTe-based gamma ray imagers
- CMOS sensors
- RF integrated circuits

## Custom Integrated Circuits

Eight-channel CMOS preamplifier-shaper for Time Expansion Chamber of the PHENIX experiment at RHIC



- Custom designed front end for high signal-to-noise
- Over 20,000 channels installed in large nuclear physics detector
- Cost < \$5/channel

Photon-counting ASIC for high-rate EXAFS studies



- 96 channels (500,000 transistors)
- 1 cm<sup>2</sup> circuit board replaces large rack-based system while delivering improved performance
- Excellent energy resolution -- 167 eV FWHM with silicon pad detector
- High rate (100,000 cps/channel)

## Multichip Modules

240-channel Silicon drift detector front end for STAR at RHIC



- 30 custom ICs in 6 x 2 cm<sup>2</sup>; 250  $\mu$ m channel pitch
- Thick film on beryllia substrate; 5 metal planes
- 530 e<sup>-</sup> rms noise
- 120,000 channels installed

## Digital data acquisition and processing

Custom design of high speed, real-time control and signal processing functions based on digital bus standards (VME, PCI, etc.)



Digital centroid-finding module for 120<sup>o</sup> thermal neutron detector for the LANSCE spallation neutron source. Onboard FPGA and DSP circuits decode the neutron position information in parallel and generate real-time display. Count rate capability 10<sup>6</sup> Hz.

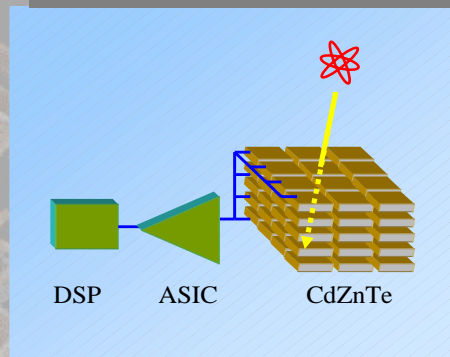
## CdZnTe-based Gamma Cameras

- Collaborative R&D project with eV Products, Inc.
- Developed high-performance integrated electronics for readout of CdZnTe detectors
- Cost, area, and power dissipation improvement of 1 - 2 orders of magnitude compared to previous hybrid and discrete implementations.

### Benefits of CdZnTe:

- Solid state
- Room temperature operation
- Direct conversion
- High stopping power
- Good energy resolution

### Proposed gamma spectrometer for detection of nuclear materials



Detectors use a matrix of inexpensive CZT detectors with CMOS ASICs and DSP to create a large effective active volume of high-Z material with excellent efficiency and energy resolution.

### Gamma ray imagers developed by eV Products, Inc. using BNL ASICs

Highly-segmented CdZnTe detectors coupled to CMOS readout chips deliver good energy resolution (< 4% FWHM at 122 keV) at high count rate (> 10<sup>6</sup> cps).



### Nuclear medicine imaging array

- 96 CZT crystals, 3072 channels



### Handheld imaging probe for intra-operative cancer detection

- 34.1 x 34.1 x 5 mm CZT detector patterned with 256 pixels.